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Smolt Production and Harvest of Coho Salmon from the Situk River, 1992–1993

by

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and

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November 1997

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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ABSTRACT

We estimated the abundance and age composition of coho salmon *Oncorhynchus kisutch* smolt leaving the Situk River in 1992 and estimated their harvest as returning adults in marine fisheries in 1993. Smolt abundance was estimated using two separate mark-recapture experiments; these two methods yielded very different estimates of abundance.

In the first experiment to estimate smolt, two 8-ft-diameter rotary screw traps were fished on the upper and lower Situk River during spring 1992. Eighteen thousand eight hundred eleven (18,811) emigrating smolt were captured at the upper trap, marked with a shallow caudal finclip, and released. At the lower trap, 22,659 smolt were captured and inspected for marks, and 766 finclipped fish were recaptured. Because complete mixing did not occur between sampling events, a Darroch estimator was used to estimate abundance at 612,034 (SE = 43,927) coho salmon smolt leaving the Situk River in 1992. In a second experiment, 37,656 smolt that had been captured in both traps and marked with coded wire tags/adipose finclips in 1992 were used as the marked event. In 1993, 1,239 adults were sampled in the Situk River, and, of these, 38 fish were missing adipose fins. Chapman's modification of the Petersen method was used to estimate that 1,197,298 (SE = 186,212) coho salmon smolt emigrated from the Situk River in 1992. We examined potential biases in each method and concluded that the smolt/adult method provided the best estimate of abundance.

The estimate of smolt age composition was stratified by three seasonal periods to account for differing sample rates over the different strata. The age composition of smolt was 68.3% (SE = 2.6%) age 1.0, 28.6% (SE = 2.5%) age 2.0, and 3.2% (SE = 1.1%) age 3.0.

The harvest of Situk River coho salmon was estimated through recoveries of coded wire tags in marine fisheries. We estimated that 49,800 (SE = 4,269) Situk River coho salmon were harvested in commercial, sport, and subsistence fisheries during 1993. Most (62.1%) of the harvest was taken in the commercial set gillnet fishery in the Situk-Ahrnklin Lagoon. The commercial troll fishery in the Northwest Quadrant and the Situk River sport fishery took 25.1% and 3.7%, respectively, of the estimated harvest. The remainder of the harvest occurred in the subsistence fishery off the mouth of the river (0.6%), Prince William Sound gillnet fisheries (2.9%), and other Yakutat gillnet fisheries (5.6%).

Key words: Coho salmon, *Oncorhynchus kisutch*, Situk River, age composition, harvest, troll fishery, set gillnet fishery, recreational fishery, migratory timing, rotary screw trap, coded wire tag, Darroch estimator, Petersen estimator, smolt production.

INTRODUCTION

The Situk River flows into the Gulf of Alaska southeast of the community of Yakutat (Figure 1). The river is 35.2 km (22 mi.) long and has two lakes at its headwaters that have a combined surface area of about 397 hectares (992 acres). The river supports a relatively large population (approximate harvest range: 10,000–100,000) of coho salmon *Oncorhynchus kisutch* important to local sport and commercial fisheries. The Situk River also supports the largest known population (escapement range: 2,500–8,500) of steelhead trout *O. mykiss* in Southeast Alaska, as well as significant populations of chinook *O. tshawytscha* (total run range: 1,000–18,000), sockeye *O. nerka* (total run range: 67,000–302,000), and pink salmon *O. gorbuscha* (total run range: 30,000–500,000), cutthroat trout *O. clarki*, Dolly Varden *Salvelinus malma*, and eulachon *Thaleichthys pacificus*.

Coho salmon life history in the Situk River is similar to that in other Alaska streams (Thedinga et al. 1993). Coho salmon typically spend one to two years as fry in fresh water and about 14 to 18 months at sea before returning to spawn. Thedinga et al. (1994) estimated that 44.2% of the coho salmon smolt emigrating from the Situk River in 1990 were age 1 and 47.8% were age 2. Thedinga et al. (1994) also estimated the number of coho salmon smolt emigrating in 1990 from the upper and lower Situk River at 230,000 (95% CI = 216,000–244,000) and 213,000 (95% CI = 187,000–238,000), respectively.

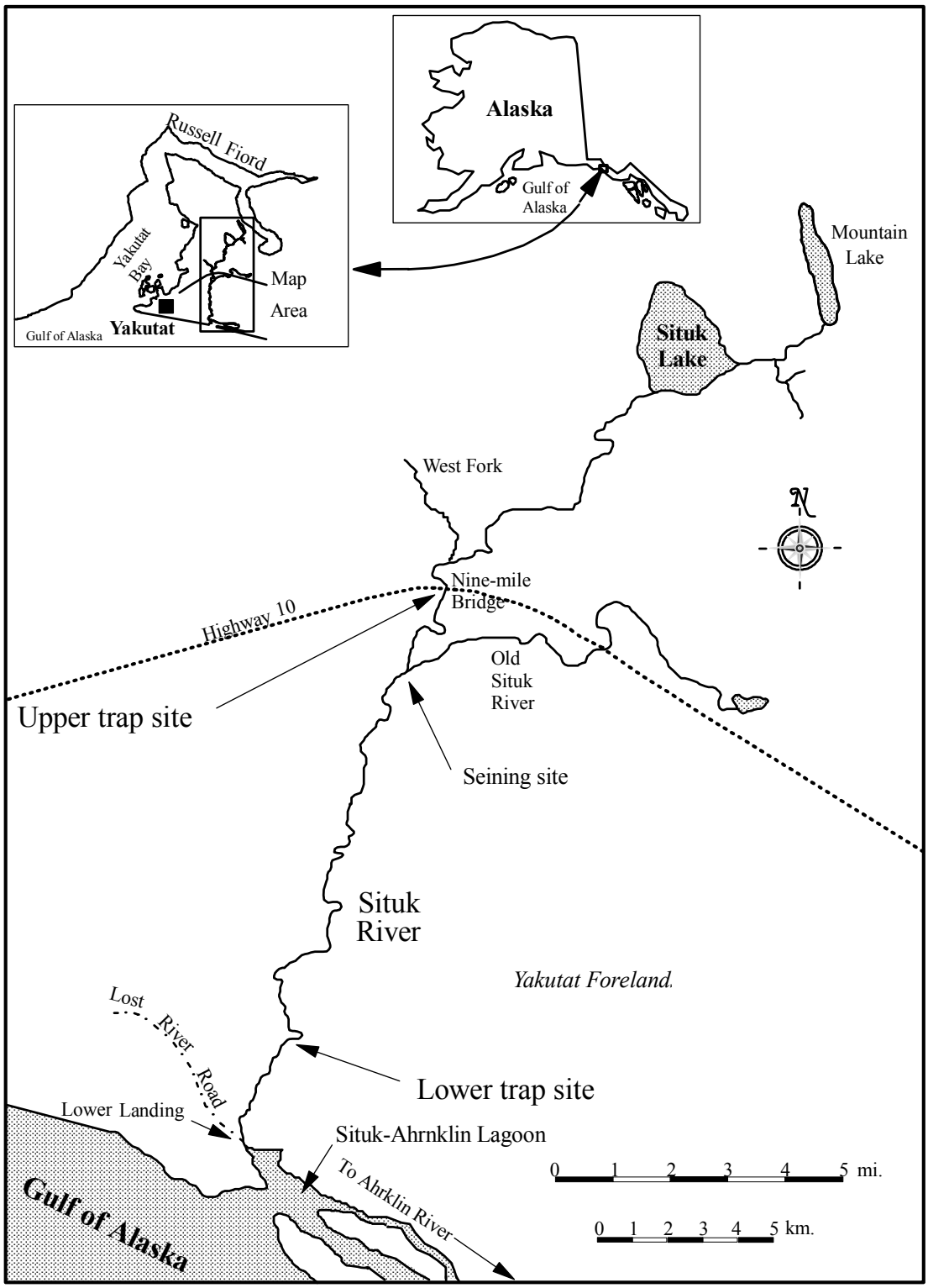

Figure 1.–The Situk River, showing the locations of the rotary screw traps operated during 1992, and inriver sampling sites for adult coho salmon during 1993.

Situk River coho salmon are targeted for harvest in the outside troll fisheries, the Situk-Ahrnklin commercial set gillnet fishery, the subsistence fishery in the Situk-Ahrnklin Lagoon, and the Situk River sport fishery. In 1985, an estimated 66.6% of the commercial harvest of Situk River coho salmon was taken in the Situk-Ahrnklin setnet fishery (Shaul et al. 1991). This fishery harvests coho salmon returning to both the Situk and the Ahrnklin rivers. The remainder of the commercial harvest of Situk River coho salmon was taken in the troll fisheries. Most (40.2% and 52.5%, respectively) of the coho salmon sampled in the Situk-Ahrnklin commercial setnet fishery between 1985 and 1988 were age 1.1 and 2.1 (Riffe et al. 1987, Pahlke and Riffe 1988, Pahlke 1989, and Rowse 1990) (Table 1).

Table 1.–Estimated age composition of coho salmon sampled in the Situk/Ahrnklin commercial setnet fishery, 1985–1988.

Harvest year	Total harvest	Sample size	Age composition (%)				
			1.0	1.1	2.1	3.1	4.1
1985[a]	55,223	528		52.3	42.8	4.9	0.1
SE[a]							
1986[b]	14,760	446		41.4	55.7	2.9	
SE				2.6	2.7	0.9	
1987[c]	30,269	440	0.2	32.4	58.7	7.8	0.8
SE			0.2	3.2	3.4	1.9	0.7
1988[d]	61,689	384		34.6	52.8	11.7	0.8
SE				2.8	3.0	2.0	0.6
Average			0.1	40.2	52.5	6.8	0.4

[a] Taken from Riffe et al. (1987). No estimates of standard errors were provided.
[b] Taken from Pahlke and Riffe (1988).
[c] Taken from Pahlke (1989).
[d] Taken from Rowse (1990).

Due to the significant production and harvest of coho salmon from the Situk River, the Alaska Department of Fish and Game (ADF&G) tagged coho salmon smolt in 1992 as part of another study directed at steelhead trout. The objectives of this study were to estimate (1) the abundance of coho salmon smolt leaving the Situk River in 1992, (2) the age composition of coho salmon smolt, and (3) the harvest of adults returning to the Situk River in marine fisheries in 1993. These objectives were accomplished by tagging and sampling smolt in 1992, and by sampling adults in 1993 in the Situk River. Other projects in our agency supplied information on returning adults that were harvested in 1993.

METHODS

SMOLT CAPTURE, CODED WIRE TAGGING, AND SAMPLING

Two 8-ft-diameter rotary smolt traps, constructed by E.G. Solutions of Corvallis, Oregon, were fished at two locations in the Situk River to capture smolt in 1992. One trap was fished from May 3 to July 1, 1992, about 20 km upstream of the estuary near the Nine-mile bridge (Figure 1). The second trap was fished from May 7 to July 5, 1992 about 3 km above the Lower Landing (Figure 1).

Each trap consisted of a cone, a livebox, two pontoons for flotation, an apparatus to lift the cone from the water, and a mechanism to clean the livebox from debris. The cone (8 ft in diameter) faced upriver, and rotary blades within the cone corkscrewed back to a narrow exit and livebox; the junction between exit and live box was sealed with a rubber collar to prevent fish from escaping. Both traps were held offshore 2–8 m by boom logs fixed to the bank and tied off by a tag line fixed to the front pontoons. In addition, each trap was secured by a safety line of ¾" polypropylene line tied to the inshore pontoon. Vexar "wing" panels were used on both sides of each trap to direct smolt toward the cone and increase capture efficiency.

Two members of a three-person crew were on duty at each trap to keep the traps fishing 24 hours a day. Each morning and evening, fine debris was removed from the cones by scrubbing them with a brush and

rinsing with water. Healthy, untagged smolt captured at each site were tagged with a coded wire tag (CWT) and marked with an adipose finclip.

Salmonid smolt and fry were removed from trap live boxes during each visit and were transported to holding boxes at camp for processing each morning. Coho salmon and steelhead trout smolt were separated by inspection from other species, which were released. All coho salmon smolt ≥70 mm fork length (FL) captured in the upper trap were separated by size (<85 mm, ≥85 and <110 mm, or ≥110 mm) and given a temporary mark by removing the tip of the upper or lower lobe of their caudal fins. The 70-mm cutpoint was selected because previous research suggested that fish over this length were smolt (Steve Elliott, Alaska Department of Fish and Game, Douglas, personal communication). The upper or lower caudal mark was alternated over time to facilitate stratification of the abundance estimate as necessary. Sorting the smolt into three size groups at the upper site allowed an appropriate head mold for coded wire tagging and allowed us to test for size selective sampling at the two sites (see below).

Initially, all coho salmon smolt captured at the lower trap site were examined for marks. An unusually strong run of eulachon moved into the lower river and plugged the lower screw trap; the lower trap was not fished between May 14 and 23 to avoid catching these fish. On May 29, daily catches at the lower trap began to get very large (thousands of fish per day) so the planned systematic sampling for length (nearest mm FL) and scales was decreased from every 20th fish to every 80th fish. On May 31, catch rates increased further so that subsamples of around 1,000 fish were taken each day to examine for marks and for further subsampling (1 in 80) for length and scales. Numbers of smolt in excess of the 1,000 or so sampled were estimated by a volumetric method based on daily counts of the number of smolt that filled the dip net used to bail the trap of excess smolt.

Coho salmon smolt ≥70 mm FL that were captured in the upper trap and smolt that were sampled for marks from the lower trap were tranquilized in a buffered solution of tricaine-methane sulfanate (MS 222) in preparation for tagging with CWTs. The solution was buffered with sodium bicarbonate until the pH was neutral as measured with a Hach kit. Smolt were tagged with a CWT and marked by excision of the adipose fin, following the methods in Koerner (1977), and released.

Midway through tagging, a random batch of 100 fish in each day's catch were held in a live box and checked for the retention of CWTs and tagging mortality after 24 hours. When fewer than 100 coho salmon smolt were caught in a day, the entire catch was held for 24 hours. The number of fish tagged, number of tagging-related mortalities, and number of fish that had shed their tags were compiled and submitted to the Commercial Fisheries Management and Development Division (CFMADD) Tag Lab in Juneau when field work ended.

ESTIMATE OF AGE COMPOSITION

The age composition of emigrating coho salmon smolt in 1992 was estimated from systematically drawn samples of smolt captured in the lower trap during five different seasonal strata. Each sampled smolt was measured to the nearest mm fork length. A smear of scales was taken two rows above the lateral line on the left side of each sampled smolt just ahead of the adipose fin (Scarnecchia 1979). Scales were mounted between two 25 mm by 75 mm glass slides and viewed through a microfiche reader at 70× magnification. Age was determined once for each fish and is reported in European notation. Proportions in the age composition of emigrating coho smolt and their variances for each stratum were estimated as

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \qquad v[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \quad (1)$$

where n_{ij} is the number of smolt in the sampled stratum i determined to be of age j, and n_i is the number of smolt successfully aged in stratum i.

Proportions in the age composition and their variances for the total coho smolt emigration were estimated as

$$\hat{p}_{ij} = \frac{\sum_i \hat{C}_{ij}}{C} \qquad v[\hat{p}_j] = \frac{\sum_i^J (V[\hat{p}_{ij}]\hat{C}_i^2)}{C^2} \qquad (2)$$

where C is the total seasonal catch of smolt in the lower trap and $\hat{C}_{ij}$ is the catch of smolt of age j in stratum i estimated by $\hat{p}_{ij}C_i$ (where C_i is the number of smolt captured in the lower trap during stratum i).

Estimate of Smolt Abundance

The abundance of smolt leaving the Situk River in 1992 was estimated using two separate mark-recapture experiments. An inseason estimate was accomplished by marking smolt captured in the upper trap and examining smolt in the lower trap for marks. This methodology was much more problematic then the postseason procedure which provided the final estimate for the experiment. The postseason estimate employed the adipose finclip applied to all CWT'd fish as the mark in a two-event mark-recapture experiment where adult coho salmon immigrating to the Situk River during the fall of 1993 were examined for missing adipose fins.

Inseason Estimate of Smolt Abundance

Upper caudal clips were applied to emigrant smolt captured in the upper trap from May 5 through May 20, and again from June 5 through June 17. Lower caudal clips were applied during the remaining periods (May 21 through June 4, and from June 18 through July 1). Nearly every captured smolt was given a caudal clip, CWT, and released. Daily counts of fish examined for caudal clips and number of fish with an upper or lower caudal clip among fish examined were tabulated for the recapture event.

The assumption that fish of different sizes were captured with equal probability was tested with a 2×2 contingency table (chi-square statistic, α = 0.05) comparing number of fish captured by size categories at each site. Counts of smolt tagged were recorded by two size groups (<110 mm or ≥110 mm) at the upper site and compared with numbers at the lower site. If the test were to suggest size selection, the mark-recapture experiment would be stratified by size group.

An assumption that every emigrant had an equal probability of being marked with a caudal clip, or that complete mixing (of marks) occurred between sampling events was evaluated by testing if the marking fraction was equal in each of three time periods. If the marked ratio changed significantly over time, a Darroch estimator (Seber 1982, Darroch 1961) was used to estimate

$$\hat{\underline{U}} = \mathbf{D_u M^{-1}} \underline{\mathbf{a}} \qquad (3)$$

where $\underline{\mathbf{U}}$ = vector of the estimated number of *unmarked* fish during each time period during the second sampling event;

$\mathbf{D_u}$ = diagonal matrix of the number of *unmarked* fish captured during each time period during the second sampling event;

$\mathbf{M}$ = matrix (m_{hi}) of the number of tagged fish recovered during time period i that were released in time period h; and

$\underline{\mathbf{a}}$ = vector of the number of marked fish released during time period h;

and abundance $\hat{N} = \hat{U} + A$ where $\hat{U}$ and A are sums of the vector elements in $\hat{\underline{U}}$ and $\underline{a}$, respectively. The variance-covariance matrix for $\hat{\underline{U}}$ was estimated using the approximation for the expected value $\mathbf{E}\left[(\hat{\mathbf{U}} - \mathbf{U})(\hat{\mathbf{U}} - \mathbf{U})'\right]$ as explained by Seber (1982, page 433).

Postseason Estimate of Smolt Abundance

Adult coho salmon that had immigrated into the Situk River were inspected for adipose finclips between September 1 and 23, 1993. Samples were from two sources: from fish harvested by sport anglers fishing from the lower landing to about 2 km upstream; and from fish taken on rod

and reel and beach seines near the confluence of the Old Situk River (Figure 1). Coho salmon with missing adipose fins were considered "marked" for this experiment. Each sampled coho salmon was given a ventral hole punch on the left operculum to prevent resampling.

The abundance was estimated using Chapman's modification of the Petersen method (Seber 1982):

$$\hat{N}_s = \frac{(n_c + 1)(n_e + 1)}{(m_e + 1)} - 1 \qquad (5)$$

$$v[\hat{N}_s] = \frac{(n_c + 1)(n_e + 1)(n_c - m_e)(n_e - m_e)}{(m_e + 1)^2 (m_e + 2)} \qquad (6)$$

where n_c = number of coho salmon smolt marked with an adipose finclip that survived after 24 hours during 1992;

n_e = number of adult coho salmon examined in the Situk River during 1993;

and

m_e = number of adults examined in 1993 that were missing adipose fins.

ESTIMATE OF HARVEST

Harvests of adult coho salmon which emigrated from the Situk River in 1992 were estimated from fish sampled from harvest in commercial fisheries, from recreational fisheries statistics (Mills 1994) and from fish sampled in the Situk River escapement (to estimate the marked fraction $\hat{\theta}$). Because several fisheries exploited coho salmon over multiple months in 1993, the commercial harvest of coho salmon from the Situk River was estimated over several strata, each a combination of time, area, and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics from drift gillnet fisheries were stratified by week and by fishing district. Estimates of the commercial harvest $\hat{r}_i$ were calculated for each stratum, then summed across strata and across fisheries to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \qquad (7a)$$

$$v[\hat{T}] = \sum_i v[\hat{r}_i] \qquad (7b)$$

Variance of the sum of estimates was estimated as the sum of variances across strata, because sampling was independent across strata and across fisheries.

A subset n_i of the commercial harvest in each stratum was counted and inspected to find recaptured fish. Of those a_i salmon in this sample without adipose fins, heads were retrieved from a subset, marked, and sent to Juneau for dissection. Of the a_i' heads that arrived in Juneau, all were passed through a magnetometer to detect a CWT. Of the t_i tags detected, t_i' were successfully decoded under a microscope after dissection of which *m* had come from the Situk River. Oliver (1990) presents details of sampling commercial fisheries.

The fraction θ of the return to the Situk River with tags was estimated from adult coho salmon sampled in the Situk River during 1993 (as described in the previous section) as the fraction of the sample composed of adults with missing adipose fins ($\hat{\theta} = m_e / n_e$).

Information from catch and field sampling programs was expanded to estimate harvest of coho salmon bound for the Situk River for each stratum. From Bernard and Clark (1996), estimated harvest and an estimate of its variance for a stratum were calculated as

$$\hat{r}_i = H_i \left(\frac{m_i}{\lambda_i n_i} \right) \hat{\theta}^{-1} \qquad (8a)$$

$$v[\hat{r}_i] = \hat{r}_i^2 \left(G[\hat{p}_i] + G[\hat{\theta}^{-1}] - G[\hat{p}_i] G[\hat{\theta}^{-1}] \right) \qquad (8b)$$

where G( ) is the squared coefficient of variation for the specified variable, H_i the catch for a stratum, $\hat{p}_i$ is the estimated fraction of catch con-

taining recovered tagged fish, and $G[\hat{p}_i]$ was calculated from Table 2 in Bernard and Clark (1996):

$$G[\hat{p}_i] = \frac{1 - \lambda_i \hat{\phi}_i \hat{\theta}}{m_i} \quad (9)$$

where ϕ_i is the fraction of catch sampled (n_i / H_i) and $\lambda_i = (a_i' t_i')/(a_i t_i)$.

The statistic $V[\hat{\theta}^{-1}]1$ was estimated from a Monte Carlo simulation (Geiger 1990). Because sampling of returning adults was spread over time, the binomial probability distribution was considered an adequate model for the recovery of tagged fish. A vector of B simulated statistics $\{\theta_1^*, \theta_2^*, \ldots \theta_B^* 2\}$ were generated by drawing B samples each of size n_e from Binom $(\hat{\theta}, n_e)$ where $\theta_b^* = m_e^* / n_e$.

Calculations followed as

$$\{\theta_1^{*-1}, \theta_2^{*-1}, \ldots, \theta_B^{*-1}\} = \{y_1^*, y_2^*, \ldots, y_B^*\} \quad (10a)$$

$$\hat{v}[\theta^{-1}]) = \frac{\sum_{b=1}^{B} \left(y_b^* - \bar{y}^*\right)^2}{B - 1} \quad (10b)$$

$$\hat{G}[\theta^{-1}] = \hat{v}[\theta^{-1}]) \hat{\theta}^2 \quad (10c)$$

where y is the subset of n_e that had no adipose fins and Situk River tags.

Estimates of Mean Date of Harvest

Estimates of the mean dates of harvest for commercial fisheries were calculated from the time series of estimated proportions of catches by strata within a fishery (Mundy 1982). The fraction of Situk River coho salmon in a fishery on day d was estimated as

$$\hat{P}_d = \frac{\hat{H}_d}{\sum_i H_i} \quad (11)$$

where $\hat{H}_d$ is the estimated number of Situk River coho salmon harvested in a fishery on day d. The mean date of harvest in each fishery over a time interval of n strata was calculated as

$$\hat{\bar{d}} = \sum_{d=1}^{n} d\hat{P}_d \quad (12)$$

RESULTS

Smolt Capture, Coded Wire Tagging, and Sampling

Of a total 19,537 coho salmon smolt captured at the upper site between May 3 and July 1, 1992 (Figure 2, top), 18,811 were given an upper or lower caudal finclip and released. Small numbers of fish (typically mortalities) were not marked. At the lower site, 52,531 coho salmon smolt were captured between May 7 and July 5, 1992 (Figure 2, bottom). In all, 37,714 smolt were given coded wire tags (17,466 at the upper site and 20,248 at the lower site) and marked by excision of the adipose fin (Table 2). We estimated that 37,656 of these survived after 24 hours and 37,541 of these retained their tags (Table 2).

Smolt and young of other species of salmon were also captured. Steelhead trout smolt were also coded wire tagged: 955 with tag code 04-37-39 and 543 with tag code 04-37-41. Also captured but not marked or tagged were eulachon, Dolly Varden, chinook, sockeye, chum, and pink salmon.

At the lower trap, 315 coho salmon smolt were scale sampled, of which 308 were successfully aged. Sampling rates varied over time, so the age composition estimate was stratified over five different time periods (Table 3). Age composition of emigrating coho salmon smolt throughout the season was estimated at 68.3% (SE = 2.6%) age-1.0, 28.6% (SE = 2.6%) age-2.0, and 3.2% (SE = 1.1%) age-3.0 (Table 3).

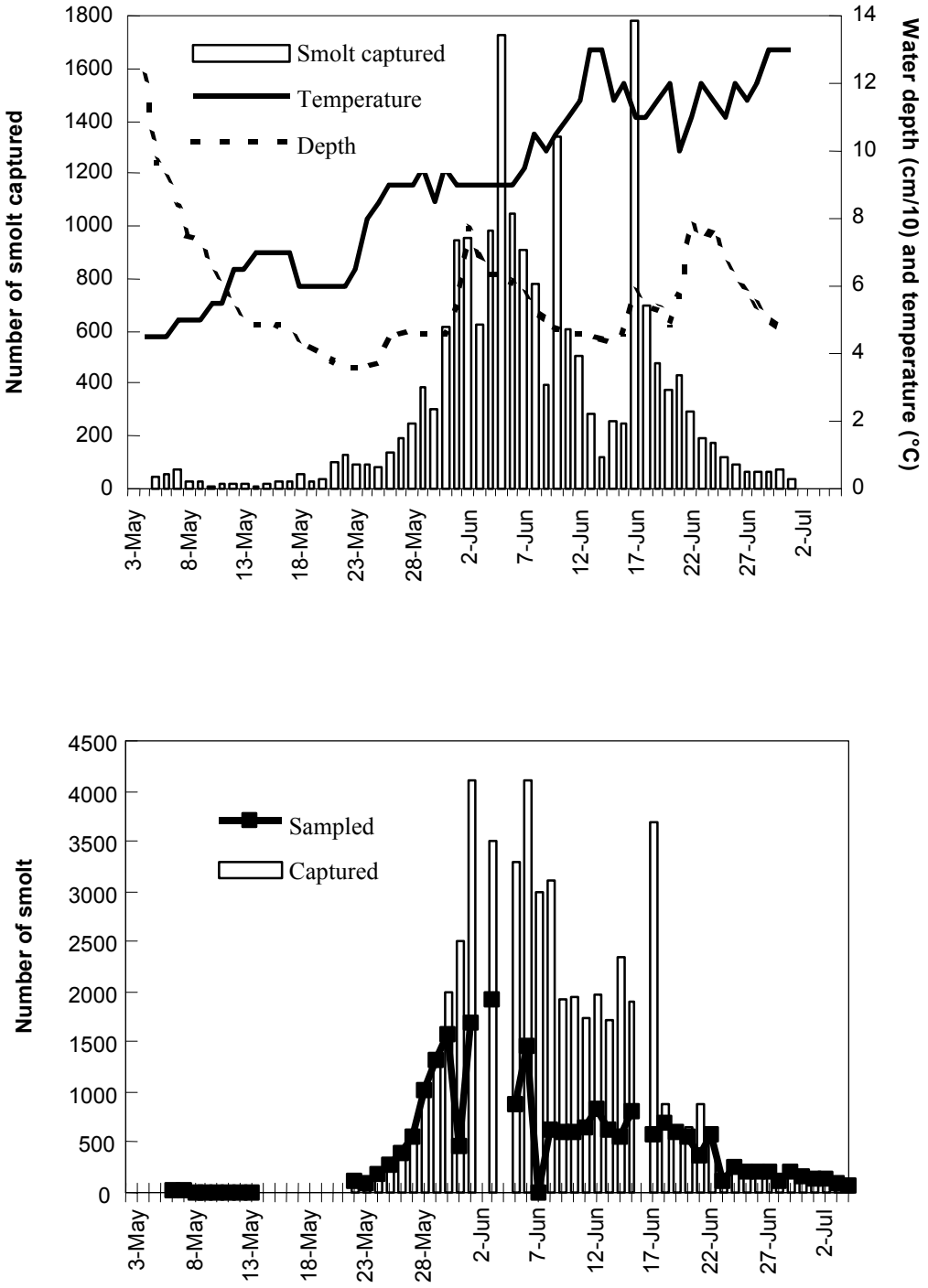

Figure 2.–Daily captures of coho salmon smolt with water temperature (ºC) and depth (cm/10) at the upper trap site (top) and daily captures and number of smolt examined for marks at the lower trap site (bottom), Situk River 1992.

Table 2.–Number of coho salmon smolt released with adipose finclips and coded wire tags, by tag code and release site, Situk River, 1992.

Site	Tag code	Number tagged [a]	Number marked [b]	Number retained [c]
Upper trap	04-28-52	1,057	1,042	1,042
Upper trap	04-33-35	5,522	5,498	5,498
Upper trap	04-37-60	10,887	10,883	10,872
Subtotal		17,466	17,423	17,412
Lower trap	04-28-52	8,489	8,478	8,468
Lower trap	04-37-61	11,759	11,755	11,661
Subtotal		20,248	20,233	20,129
Total		37,714	37,656	37,541

[a] Number of smolt marked with an adipose finclip and CWT and released.

[b] Estimated number of smolt that survived after 24 hr.

[c] Estimated number of marked smolt which survived and retained CWT after 24 hr.

INSEASON ESTIMATE OF SMOLT ABUNDANCE

Of the smolt captured in the lower trap, 22,659 were inspected for caudal finclips (Figure 2, bottom), and 776 of those examined for marks had been previously marked at the upper site (Figure 3).

We examined lengths of smolt captured in upper and lower traps to determine if the traps were size selective. We could not reject the hypothesis that the length distribution of smolt marked in the upper river was the same as the distribution of marked fish recaptured in the lower river ($\chi^2 = 0.06$, $df = 1$, $P = 0.814$). This suggests that the second sampling event was not size selective. Similarly, we could not reject the hypothesis that the length distribution of smolt captured in the upper river was the same as the distribution of those captured in the lower river ($\chi^2 = 3.41$, $df = 1$, $P = 0.069$). Thus, the marking event was also considered not size selective.

Some mixing of fish between time periods did occur (Table 4). However, the hypothesis of similar marked fractions across time periods was soundly rejected ($\chi^2 = 306.4$, $df = 2$, $P < 0.001$, Figure 4), suggesting that Darroch's estimator

Table 3.–Estimated age composition of coho salmon smolt emigrating from the Situk River and captured in the lower river trap by time period, 1992.

Age	Number sampled (n_{ij})	Percent ($\hat{p}_{ij}$)	SE ($\hat{p}_{ij}$)	Catch ($\hat{C}_{ij}$)	SE ($\hat{C}_{ij}$)
Stratum 1 (May 8 to May 28) Mean sample rate = 0.04677					
1	20	25.3	4.9	428	83
2	50	63.3	5.5	1,069	92
3	9	11.4	3.6	192	61
Total	79	100.0		1,689	
Stratum 2 (May 29 to June 6) Mean sample rate = 0.00591					
1	42	40.0	4.8	7,101	853
2	58	55.2	4.9	9,806	866
3	5	4.8	2.1	845	371
Total	105	100.0		17,752	
Stratum 3 (June 7 to June 15) Mean sample rate = 0.00320					
1	56	80.0	4.8	17,494	1,053
2	12	17.1	4.5	3,749	992
3	2	2.9	2.0	625	439
Total	70	100.0		21,868	
Stratum 4 (June 16 to June 24) Mean sample rate = 0.00525					
1	47	95.9	2.9	8,961	267
2	2	4.1	2.9	381	267
3	0	0.0	0.0	0	0
Total	49	100.0		9,342	
Stratum 5 (June 25 to July 5) Mean sample rate = 0.00266					
1	5	100.0	0.0	1,880	0
2	0	0.0	0.0	0	0
3	0	0.0	0.0	0	0
Total	5	100.0		1,880	
Combined strata					
1	170	68.3	2.6	35,863	1,384
2	122	28.6	2.6	15,005	1,347
3	16	3.2	1.1	1,663	577
Totals, combined strata	308	100.0		52,531	

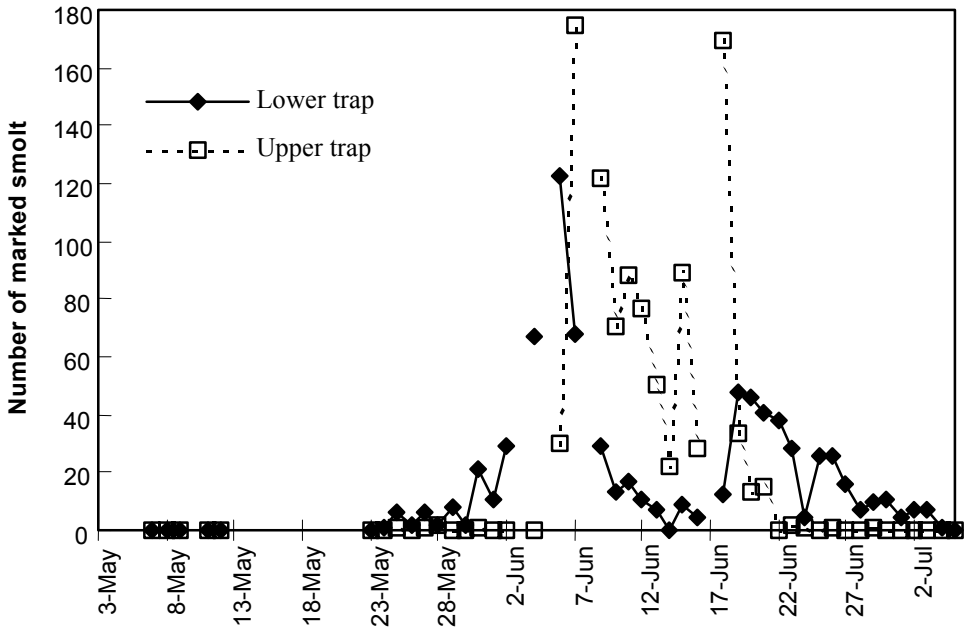

Figure 3.–Number of marked coho salmon smolt recovered at the lower trap site by type of caudal clip, Situk River 1992.

Table 4.–Numbers of coho salmon smolt recovered by marking and recovery time period (m_{hi}), marked (caudal clip) by time period (a_h), and unmarked captures in the lower trap by time period (u_i), Situk River, 1992. Bottom numbers were weighted (expanded) to correct for nonproportional sampling.

ORIGINAL CATCH DATA

Clip type	Marking dates	Recovery period			a_h
		May 21–June 4	June 5–June 17	June 18–July 1	
Lower	May 21–June 4	95	83	0	5,796
Upper	June 5–June 17	0	234	84	9,760
Lower	June 1–July 1	0	0	275	2,782
	Sum m_{hi}	95	317	359	771
	u_i	9,548	7,314	4,973	21,835
	Examined	9,643	7,631	5,332	22,606

EXPANDED STATISTICS

Clip type	Marking dates	Recovery period			a_h
		May 21–June 4	June 5–June 17	June 18–July 1	
Lower	May 21–June 4	156	280	0	5,796
Upper	June 5–June 17	0	751	237	9,760
Lower	June 18–July 1	0	0	332	2,782
	Sum m_{hi}	156	1,031	568	1,755
	u_i	15,932	23,043	8,748	47,723
	Examined	16,088	24,074	9,316	49,478

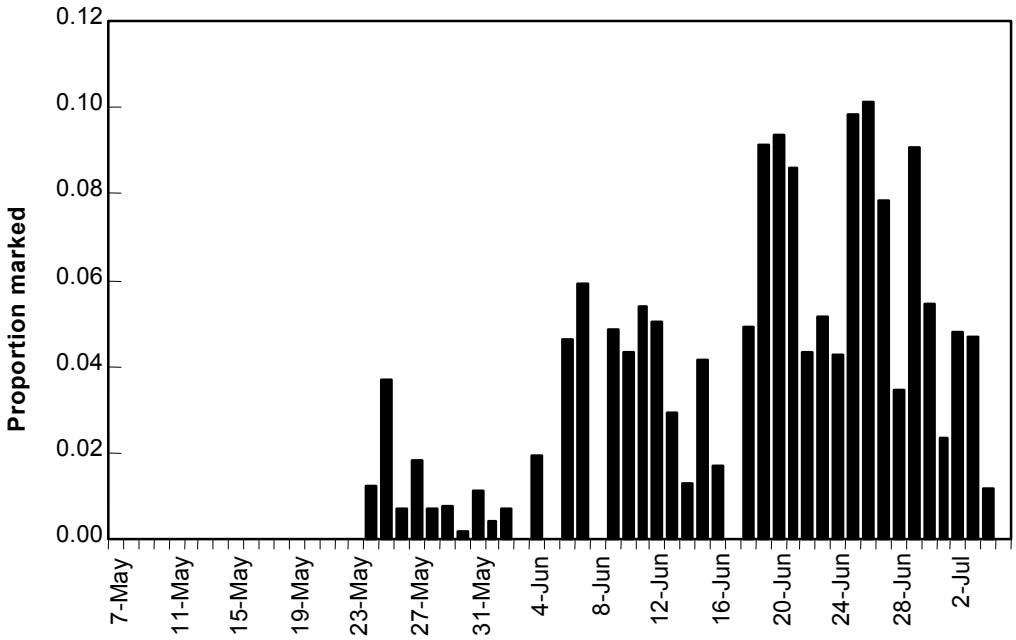

Figure 4.–Proportion of coho salmon smolt examined at the lower trap site that were previously marked with a caudal clip at the upper trap, Situk River 1992.

should be used to calculate the inseason abundance estimate. A complicating factor in the analysis was that unequal fractions of the catch were sampled for marks each day during the middle of the season (Figure 5). Since the marked fraction of mark types changed over time (Figures 3 and 4), daily samples within strata should be weighted by actual catches (Table 4) to correct for the non-proportional sampling to avoid a biased estimate. Also, because sampling for marks was suspended during mid-May, recaptures of the 473 smolt marked with upper caudal clips in the first marking strata was lost. Thus, this stratum was removed from the experiment. The inseason estimate of coho salmon smolt leaving Situk River in 1992 was 612,034 (SE = 43,927). This estimate does not differ significantly from an estimated 626,087 smolt produced by expanding daily catches to yield proportional samples (because the estimates were so similar and the precision about the latter would be difficult to calculate, the precision was not estimated). Thus, the three level stratification scheme was effective at breaking the trends in the marked fraction and mark type changes over time. These results indicate that the inseason estimate is biased low by approximately 2%. However, the variance of the expanded estimate is biased low because very few fish were actually inspected than the expanded numbers imply.

ESTIMATE OF ❑ AND THE POSTSEASON ESTIMATE OF SMOLT ABUNDANCE

We sampled 1,239 adult coho salmon in the Situk River between September 1 and 23, 1993 (Appendix A1). Thirty-eight (38) of these were missing adipose fins (marked). The proportion of adipose finclipped adults observed in the adult escapement prior to September 13 did not differ significantly from that observed during the latter part of the month (χ^2 = 0.18, *df* = 1, *P* = 0.693). Thus, data from the two recovery periods were combined. The estimate of θ was 0.0307 (= 38/1239) with SE = 0.0049. Using Chap-man's modification of the Petersen

method, we estimated that 1,197,298 (SE = 186,212) coho

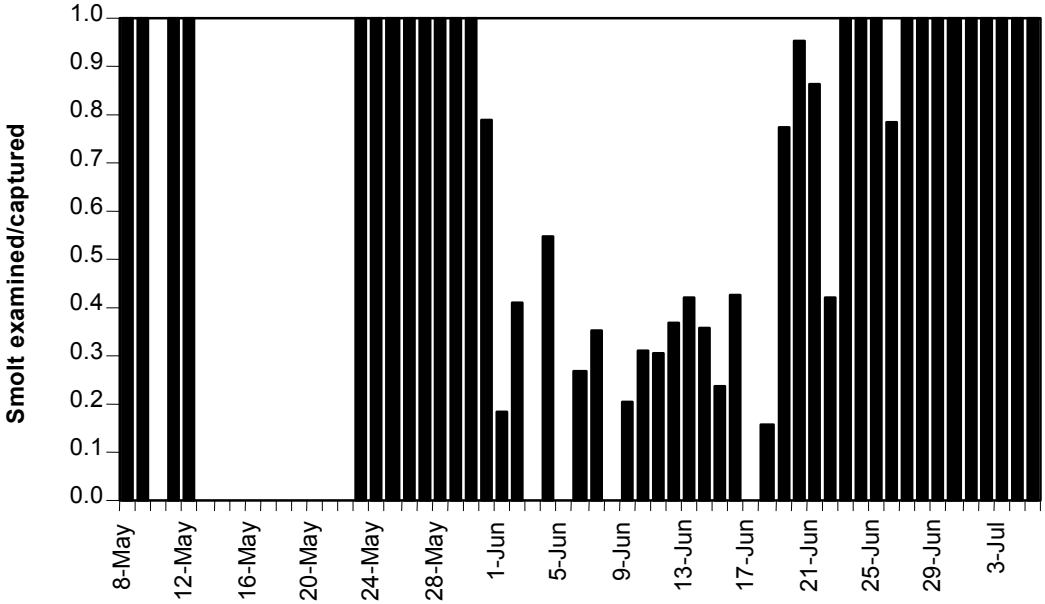

Figure 5.–Daily fraction of coho salmon smolt captured at the lower river trap that were examined for marks, Situk River 1992.

salmon smolt emigrated from the Situk River in 1992 (n_c = 37,656, n_e = 1,239 , m_e = 38).

CODED WIRE TAG RECOVERY

In 1993, 265 CWTs bearing the codes 04-28-52, 04-33-35, 04-37-60, 04-37-61 and 04-37-41 were recovered by randomly sampling commercial catches (Appendix A2). Most (156) tags were recovered from the set gillnet fisheries in the Yakutat Foreland area, with 143 from the Situk-Ahrnklin Lagoon (District/Subdistrict 182-70), 10 from the Lost River (182-80), two from Yakutat Bay (183-10), and one from the Akwe River (182-40). In the troll fishery, 92 tags were recovered, all from the Northwest Quadrant on the outside coast (Figure 6). Seventeen CWTs were recovered in the Bering River and Copper River gillnet fisheries in Prince William Sound.

Coho salmon bearing the different Situk River tag codes were recovered with similar relative frequencies in Yakutat set gillnet fisheries from July 17 to October 1, and in the Northwest Quadrant troll fishery from July 17 to September 24 (Table 5). This indicates that tagged fish mixed well in the ocean environment. The percent of tags recovered in these two fisheries was 0.64% for all four coho tag codes, with 0.40% recovered in the gillnet and 0.24% recovered in the troll fisheries.

ESTIMATES OF HARVEST IN 1993

An estimated 47,647 (SE = 4,241) Situk River coho salmon were harvested in commercial fisheries in 1993 (Table 6). An additional 1,858 (SE = 366) coho salmon were harvested by sport anglers in the Situk River (Mills 1994), 296 (SE = 366) were harvested by subsistence fishers in the Situk-Ahrnklin Lagoon (1,424 were reported in the subsistence harvest but only 21% were assumed to be Situk River fish), for a total harvest of 49,801 (SE = 4,269). The set gillnet fishery in the Situk-Ahrnklin Lagoon harvested 62.1% of the total, while gillnet gear in all areas accounted for 70.6% of the total, including 2.9% in Prince William

Sound (Table 7). The troll fishery in the Northwest Quadrant took 25.1% of the estimated harvest (Table 7), all from Cross Sound and further north. It is apparent that Situk River coho salmon travel

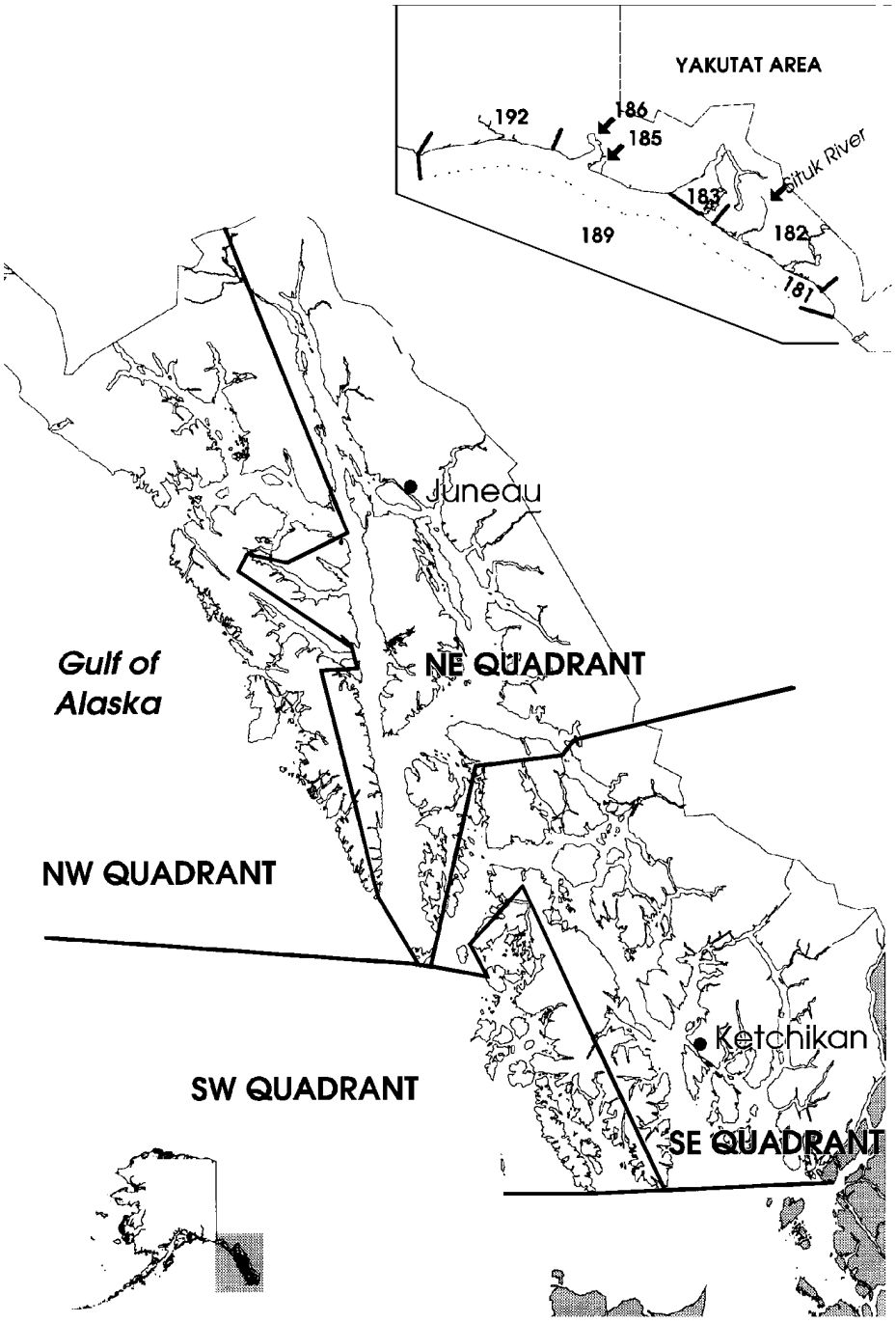

Figure 6.–Locations of the troll fishery management areas.

from west and north of the Yakutat area on their return migration and that landfall is north of Cross Sound.

Harvests in the troll and gillnet fisheries occurred from mid-July through early September (Figure 7). Most (76%) of the troll harvest

Table 5.–Recoveries of CWTs from Situk River coho salmon in Yakutat gillnet fisheries and the Northwest Quadrant troll fishery in 1993.

Stat week	Ending date	Tag code 04-28-52	Tag code 04-33-35	Tag code 04-37-60	Tag code 04-37-61	Tag code 04-37-41[a]	Total tags
YAKUTAT GILLNET FISHERIES							
32	8/07				1		1
33	8/14						0
34	8/21						0
35	8/28	1	1	5	1		8
36	9/04	4	1	7	6		18
37	9/11	2	4	10	12		28
38	9/18	10	5	12	15	2	44
39	9/25	2	6	6	10	3	27
40	10/02	9	5	6	10		30
	Gillnet subtotal	28	22	46	55	5	156
NORTHWEST QUADRANT TROLL							
29	7/17	1					1
30	7/24	2	2		2		6
31	7/31	1		1			2
32	8/07	3		3	2	1	9
33	8/14	4		1	3		8
34	8/21						0
35	8/28	4	5	5	3		17
36	9/04	5	4	4	8		21
37	9/11	2		3	3		8
38	9/18	3	1	6	6	2	18
39	9/25				2		2
40	10/02						0
	Troll subtotal	25	12	23	29	3	92
Total gillnet/troll tags recovered							0
Tags released		9,510	5,498	10,872	11,661		37,541
Percent recovered gillnet		0.294	0.400	0.423	0.472		0.402 [b]
Percent recovered troll		0.263	0.218	0.212	0.249		0.237 [b]
Percent recovered gillnet + troll		0.557	0.618	0.635	0.720		0.639 [b]

[a] Steelhead trout tag code (see Discussion).

[b] Does not include coho tagged with steelhead code and recovered as coho salmon.

occurred between August 22 and September 25; 99% of the Yakutat gillnet harvests occurred after August 21. The estimated mean date of harvest in the troll fishery was August 27, compared to September 5 for gillnet fisheries in Prince William Sound, and September 12 for the Yakutat gillnet fisheries. We estimated that 50% of the total harvest was taken by September 8.

The relative importance of this stock to the total harvest varied with the fishery. We estimated that Situk River coho salmon contributed 21% (30,923 fish) of the District 182-70 (Situk/ Ahrnklin rivers) gillnet harvest (149,083 fish)

and 25% (2,280/9,310) of the Lost River coho salmon harvest (Table 6).

The Lost River is immediately adjacent to the Situk River, and some Situk River fish temporarily hold in the Lost River lagoon before proceeding to the Situk River. We assume that all (1,858) of the coho salmon harvested in the

Table 6.–Estimated commercial harvest of adult coho salmon bound for the Situk River in 1993. In fishing periods and fishing quadrants for which no CWT was recovered with the appropriate code, harvest was assumed to be zero.

Fishery	District	Sub-district	Stat. week	Harvest	*n*	*a*	*a'*	*t*	*t'*	*m*	Contribution	
											r	SE
Yakutat gillnet	183	10	32	136	39	1	1	1	1	1	114	113
Yakutat gillnet	182	70	35	6,035	602	8	8	8	8	6	1,959	857
Yakutat gillnet	182	80	35	6,035	602	8	8	8	8	2	653	468
Yakutat gillnet	182	70	36	15,587	2,390	20	20	18	18	18	3,824	1,108
Yakutat gillnet	182	70	37	34,057	3,118	32	31	28	28	25	9,182	2,411
Yakutat gillnet	182	80	37	34,057	3,118	32	31	28	28	3	1,102	654
Yakutat gillnet	182	40	38	34,202	6,962	50	50	44	44	1	160	160
Yakutat gillnet	182	70	38	34,202	6,962	50	50	44	44	43	6,881	1,580
Yakutat gillnet	182	70	39	39,795	5,466	43	42	27	27	27	6,555	1,685
Yakutat gillnet	182	70	40	19,407	6,303	44	42	29	29	24	2,522	669
Yakutat gillnet	182	80	40	19,407	6,303	44	42	29	29	5	525	248
Yakutat gillnet	183	10	40	870	122	1	1	1	1	1	232	232
Yakutat gillnet subtotal				**243,790**	**41,987**	**333**	**326**	**265**	**265**	**156**	**33,709**	**3,789**
PWS gillnet	212	0	29	4,385	1,963	19	18	16	16	1	77	76
PWS gillnet	212	0	35	54,639	9,768	14	14	4	4	1	182	182
PWS gillnet	212	0	36	54,139	22,139	27	27	14	14	4	159	165
PWS gillnet	200/212		36	80,905	46,022	68	68	38	38	1	57	57
PWS gillnet	200	20	37	14,459	7,903	14	14	3	3	3	179	105
PWS gillnet	212	0	37	31,496	12,706	20	20	8	8	1	81	80
PWS gillnet	200	20	38	36,133	14,818	30	27	14	14	2	177	126
PWS gillnet	200/212		38	100,312	46,261	105	101	35	25	2	206	147
PWS gillnet	202	11	39	40,314	13,365	40	40	14	14	1	98	98
PWS gillnet	200/212		39	73,715	37,268	72	72	18	18	1	64	64
PWS gillnet subtotal				**490,497**	**212,213**	**409**	**401**	**164**	**154**	**17**	**1,439**	**372**
NW troll period 4			26-33	798,463	225,044	3,537	3,497	2,993	2,991	26	3,041	789
NW troll period 5			34-37	481,416	110,451	2,219	2,206	1,919	1,919	46	6,569	1,487
NW troll period 6			38-41	195,533	44,327	1,015	1,010	914	914	20	2,888	809
NW troll subtotal				**1,475,412**	**379,822**	**6,771**	**6,713**	**5,826**	**5,824**	**92**	**12,499**	**1,867**
Total all areas				**2,209,699**	**634,022**	**7,513**	**7,440**	**6,255**	**6,243**	**265**	**47,647**	**4,241**

Situk River recreational fishery originated from the Situk River and accounted for 4% of the total harvest of this stock; almost all of the Situk sport harvest is taken in the Situk River, well above the mixed-stock zone of the commercial fishery

The two methods of estimating smolt abundance in this study produced very different results. The postseason estimate of 1,197,298 (SE = 186,212) is nearly twice that of the inseason estimate (612,034, SE = 43,927) and over five times the 1990 inseason estimate of 213,000 smolt (Thedinga et al. 1994).

DISCUSSION

Differences between estimates obtained inseason and postseason are not unique to this study. In 1989, Elliott and Sterritt (1990) estimated the Yehring Creek coho salmon smolt abundance inseason at 24,577 (SE = 1,276) from a mark-recapture experiment based on the Petersen model. However, after inspection of returning adults a year later, they estimated the 1989 smolt production at 76,979 (SE = 6,574), speculating that the difference between marked fractions in 1989 and 1990 (0.38 and 0.13, respectively) may have resulted from unmarked smolt residing below the recapture sites, non-random distribution of marked fish, or selective recapture of fish marked in 1989 (Elliott and Sterritt 1991).

Table 7.–Harvest of Situk River coho salmon in Alaska fisheries in 1993.

Fishery	Area	Estimated harvest	SE	% of harvest
U.S. troll fishery:	NW Quadrant	12,499	1,867	25.1
	Subtotal	12,499	1,867	25.1
Gillnet:	Akwe (182-40)	160	160	0.3
	Situk-Ahrnklin (182-70)	30,923	3,682	62.1
	Lost (182-80)	2,280	842	4.6
	Yakutat Bay (183-10)	346	258	0.7
	Prince William Sound (200/212)	1,439	372	2.9
	Subtotal	35,148	3,808	70.6
Recreational[a]:	Situk River	1,858	366	3.7
	Subtotal	1,858	366	3.7
Subsistence[b]:	Situk-Ahrnklin Lagoon	296		0.6
	Subtotal	296		0.6
	Total harvest	49,801	4,269	100.0

[a] Taken from Mills (1994).

[b] Estimated by multiplying the total subsistence harvest (1,424: Gordon Woods, ADF&G, Yakutat, personal communication) by the proportion of Situk River coho salmon harvested in the District 182-70 commercial harvest (1,424 ◈ 30,923 / 149,083).

The trap efficiency method (another estimator based on inseason recapture of marks) is widely used to estimate smolt abundance. In this method, fish captured in a trap are marked, transported upriver, and released. A two-event mark-recapture experiment can thus be conducted by marking and recapturing fish using one trapping site. However, research at Deep Creek (Kenai Peninsula) suggests that time-of-day of release can affect recapture rates of chinook salmon smolt (Terry Bendock, Alaska Department of Fish and Game, Soldotna, personal communication). If coho salmon smolt behave similarly, the trap efficiency method could produce biased estimates of abundance for this species if marked fish are not released randomly throughout the day and night.

Accurate use of the two-event mark-recapture estimators requires that either: (1) every fish has an equal probability of being marked during

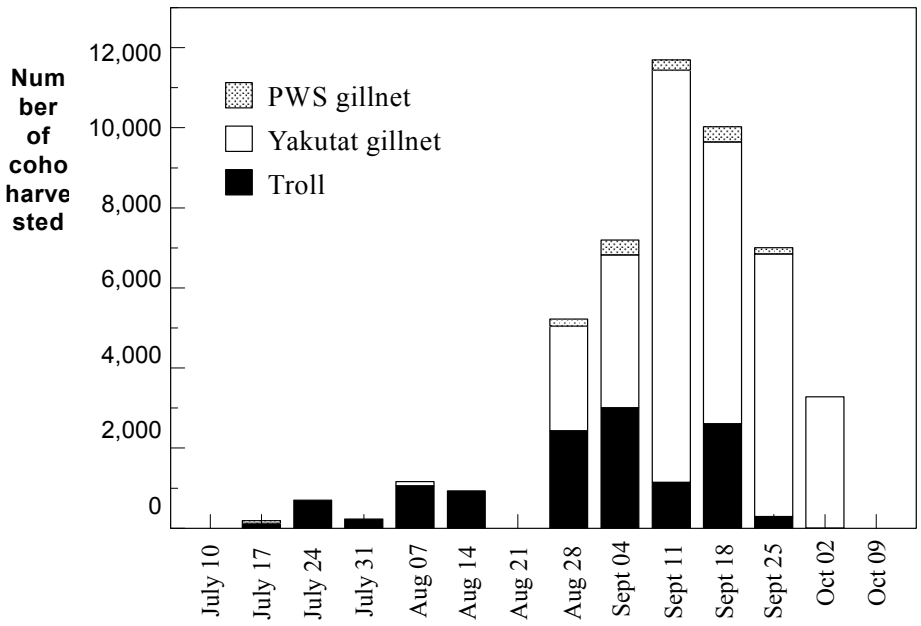

Figure 7.–Estimated harvest of Situk River coho salmon in the commercial fisheries by statistical week, 1993.

the first event; (2) every fish has an equal probability of capture during the second event; or (3) that marked fish mix completely with unmarked fish between sampling events. Since fractions of marked fish changed significantly over time, the first assumption was clearly violated during both the inseason and postseason experiments. This was due, in part, to the fact that considerable rearing habitat exists between the two trap sites: the Old Situk River, for instance, flows into the river well below the upper trap site and is thought to produce a large number of coho salmon smolt (Thedinga et al. 1991).

Assumption (3) was violated, and possibly assumption (2) also, for the inseason estimate. Complete mixing of marked and unmarked fish over time (assumption 3) was clearly impossible, so the Darroch estimator was employed for the inseason abundance estimate, in order to account for changes in marked to unmarked ratios at the lower trap. Our tests do not suggest that smolt avoided our lower trap (assumption 2). However, marked fish were released at the upper site at night. If time-of-day of release affects recapture rates of coho salmon smolt, the inseason estimate would be biased by an unknown amount.

For the postseason smolt estimate, we do not believe that there was a significantly higher mortality of marked fish relative to unmarked fish between the two sampling events (assumption 2). Less than 0.2% of the fish that we held for tag retention died after 24 h, and those that did were removed from the experiment. Other studies have also shown that CWT'd coho salmon smolt do not have significantly higher mortality than unmarked smolt (Vincent-Lang 1993). Thus, we believe assumption (2) was satisfied in the postseason experiment. We also believe that marked fish mixed very well while at sea (assumption 3). The pattern of recovery of CWTs in commercial fisheries indicates marked fish mixed significantly with unmarked fish during their 14 to 16 months at sea (Table 5). In addition, the proportion of adipose finclipped adults observed in the adult escapement did not change significantly over time (see Results Section). Finally, whereas the population in the postseason experiment was not closed to mortality, it was closed to recruitment, because salmon return to their natal stream to spawn. Under these conditions, the postseason experiment should

produce an unbiased estimate of the number of smolt leaving the Situk River in 1992.

One experimental difficulty in the postseason experiment was that 11 adult coho salmon were recovered in 1993 with a tag code that had been used for marking steelhead trout smolt in 1992. Steelhead trout smolt are much larger than coho salmon smolt and are distinctly different in appearance. We believe that the discrepancy occurred because a coded wire tag spool used to mark steelhead trout smolt at the lower site (04-37-41) was mistakenly installed in the CWT machine for one day instead of wire with coho salmon tag code 04-37-61. Since 37,541 coho salmon smolt were given a CWT in 1992 and 265 adults were recovered from that tagging, we reason that 1,558 coho salmon smolt were tagged with the incorrect code (37,541/265x11 = 1,558). This corresponds to about one day's tagging during the peak of the season at the lower site. This is consistent with the observation that the number of coho salmon smolt reported tagged with code 04-37-61 is 1,759 more than guaranteed by the manufacturer (Table 2). Thus, we believe that about 1,500 coho salmon were incorrectly tagged with code 04-37-41, but were correctly counted as coho salmon. Therefore, we believe that our postseason estimate of abundance was not affected by this error, because the estimate was based on adipose finclips as the mark.

A second experimental difficulty occurred because some chinook salmon smolt captured at the lower site were mistakenly tagged as coho salmon smolt. There has been one recovery of a chinook salmon in 1993 and two in 1994 from a code reserved for coho salmon tagged at the lower trap site in 1992 (04-37-61). Chinook and coho salmon smolt are similar in appearance and difficult to separate. However, since most (up to 98%) of Situk River chinook salmon smolt migrate to sea at age 0 (Johnson et al. 1992), most are well below our marking threshold for coho salmon (70 mm FL). Thus, we do not believe that large numbers of chinook salmon were mistakenly marked during this experiment. These discrepancies tend to bias our postseason estimate high by a small but unknown amount but do not affect our estimates of the coho salmon harvest.

We examined the possibility that some coho salmon fry were tagged in our experiments. However, no adult coho salmon were recovered in 1994 with CWTs from the 1992 tagging, despite extensive sampling (about 20%) of the commercial troll harvest. We are therefore confident that significant numbers of coho salmon fry were not tagged during 1992.

Most (68.3%, SE = 2.6%) of the smolt emigrating from the Situk River in 1992 were estimated to be age 1.0. This differs from the age composition observed in 1990. Thedinga et al. (1993) estimated that 44.2% of the smolt that year were age 1.0, and 47.8% were age 2.0. Our results also indicate older smolt tend to emigrate earlier in the season than younger smolt (Table 3).

The models used to estimate salmon harvest are based on sampling as a random process, yet our capture of smolt inriver and the catch sampling of harvests were not random, but systematic. Like two-event mark-recapture experiments, representative samples can be drawn with a systematic process only if (1) every smolt has an equal chance of being marked, (2) every adult has an equal chance of being sampled, or (3) marked and unmarked fish mix completely between sampling events. Since smolt rearing upstream of the upper site were more likely to be tagged than those rearing downstream (see above discussion concerning the postseason estimate), assumption (1) was violated. However, the other assumptions appeared reasonable in this experiment. The drawn-out recoveries of CWTs indicate considerable mixing of marked and unmarked coho salmon while at sea. Recoveries of CWTs from all tag codes in the Yakutat gillnet and offshore troll fisheries were spread throughout these fisheries, though generally not present in small harvests in the gillnet fisheries prior to statistical week 35. While the evidence of mixing between marked and unmarked fish can be detected through inspecting the temporal pattern of recovered tags, sufficiency of that mixing cannot. If mixing had been complete, the marked fraction ($\hat{\theta}$)3 would be time invariant. Although we could not detect a difference in $\hat{\theta}$

with time (see above discussion), the power of the test was low since relatively few coho salmon were recaptured in the recovery effort in 1993, and, whereas many fish were recovered in the samples from the harvest in District 182-70 (Situk-Ahrnklin), harvest of any coho salmon in District 182-70 not bound for the Situk River would cloud any inference drawn from the fishery as to variability in $\hat{\theta}$.

Our estimates of the total harvest of coho salmon bound for the Situk River in 1993 may be considered minimum estimates, since not all fisheries are sampled, and some may be sampled at rates low enough to prevent detection of small harvests. For example, catches of coho salmon in the commercial set gillnet fishery in the saltwater estuary off the Lost River adjacent to the Situk River were estimated to be composed of 25% Situk River fish (Table 6). Some of the 539 fish harvested by sport fishers in the Lost River itself were probably of Situk River origin, but we had no means to estimate that component, as those fish were not sampled for CWTs. In addition, the subsistence harvest estimate may be low, because the proportion of Situk River fish in the harvest was assumed to be the same as the commercial fishery. Because the subsistence fishery occurs immediately off the mouth of the Situk River (Gordon Woods, Alaska Department of Fish and Game, Yakutat, personal communi-cation), we expect that it harvests a greater proportion of Situk River coho salmon than the commercial fishery, distributed throughout the lagoon.

The results of our two smolt production estimates combined with similar results from Yehring Creek (Elliott and Sterritt 1990, 1991) indicate that estimates derived from fish marked and recaptured in freshwater systems are biased low. More research is needed to determine how and why this occurs. If this or a similar project is done again, different sampling gear should be used that captures fish in proportion to their abundance throughout the day, or marked fish should be released randomly throughout the day. Closer attention must be paid to species identification and the use of correct tag codes for smolt tagging. Finally, escapement should be estimated in the year when adult coho salmon are recovered, in order to provide estimates of the exploitation rate.

Appendix A3 contains a list of computer data files used in this analysis. Copies of these files can be obtained through the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services (RTS) Section, in Anchorage.

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LITERATURE CITEDCITED

Buckland, S. T., and P. H. Garthwaite. 1991. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. Biometrics 47:255-268.

Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48:241-160.

Efron, B. I. 1982. The jackknife, the bootstrap and other resampling plans. Society for Industrial and Applied Mathematics, CBMS-NSF Regional Conference Series in Applied Mathematics, No. 38.

Elliott, S. T. and D. A. Sterritt. 1990. Coho salmon studies in Southeast Alaska, 1989; Chilkoot Lake, Yehring Creek, Auke Lake, Vallenar Creek. Alaska

Department of Fish and Game. Fishery Data Series No. 90-53, Anchorage, Alaska.

Elliott, S. T. and D. A. Sterritt. 1991. Coho salmon studies in Southeast Alaska, 1990; Auke Lake, Chilkoot Lake, Nahlin River, and Yehring Creek. Alaska Department of Fish and Game. Fishery Data Series No. 91-43, Anchorage, Alaska.

Geiger, H. J. 1990. Parametric bootstrap confidence intervals for estimating contributions of to fisheries from marked salmon populations, p. 667-676 *in* Parker, N. C., A. E. Giorgi, R. C. Heidinger, D. B. Jester, Jr., E. D. Prince, and G. A. Winans, eds., Fish Marking Techniques, American Fisheries Society Symposium No. 7, American Fisheries Society, Bethesda, Maryland.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Johnson, S. W., J. F. Thedinga, and K. V. Koski. 1992. Life history of juvenile ocean-type chinook salmon (*Oncorhynchus tshawytscha*) in the Situk River, Alaska. Can. J. Aquat. Sci. 49:2621-2629.

Koerner, J. F. 1977. The use of the coded-wire tag injector under remote field conditions. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 172, Juneau.

Mills, M. J. 1994. Harvest, catch and participation in Alaska Sport Fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Mundy, P. R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. North American Journal of Fisheries Management 2:359-370.

Oliver, G. T. 1990. Southeast Alaska port sampling project. Annual report for the period July 1, 1989 to June 30, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 1J90-34, Juneau.

Pahlke, K. A. 1989. Compilation of catch, escapement, age, sex, and size data for salmon returns to the Yakutat area in 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 89-22, Juneau.

Pahlke, K. A., and R. R. Riffe. 1988. Compilation of catch, escapement, age, sex and size data for salmon returns to the Yakutat area in 1986. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 224, Juneau.

Riffe, R. R., S. A. McPherson, B. W. Van Alen, and D. N. McBride. 1987. Compilation of catch, escapement, age, sex, and size data for salmon (Oncorhynchus) returns to the Yakutat area in 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 210, Juneau.

Rowse, M. L. 1990. Compilation of catch, escapement, age, sex, and size data for salmon returns to the Yakutat area in 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 90-13, Juneau.

Scarnecchia, D. L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Progressive Fish Culturist 41 (3):132-135.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters, second edition. MacMillan and Company, New York.

Shaul, L. D., P. L. Gray, and J. F. Koerner. 1991. Coded wire tag estimates of abundance, harvest, and survival rates of selected coho salmon stocks in Southeast Alaska, 1981-1986. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Research Bulletin No. 91-05, Juneau.

Thedinga, J. F., S. W. Johnson, K V. Koski, and A. S. Feldhausen. 1991. Downstream migration of juvenile salmonids in Old Situk River, Southeast Alaska, 1989. National Marine Fisheries Service. NOAA Technical Memorandum NMFS F/NWC-199. Juneau.

Thedinga, J. F., S. W. Johnson, K V. Koski, J. M. Lorenz, and M. L. Murphy. 1993. Potential effects of flooding from Russell Fiord on salmonids and habitat in the Situk River, Alaska. National Marine Fisheries Service. AFSC Processed Report 93-01. Juneau.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, and K V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska. North American Journal of Fisheries Management 14:837-851.

Vincent-Lang, D. 1993. Relative survival of unmarked and finclipped coho salmon from Bear Lake, Alaska. The Progressive Fish Culturist 55:146-148.

APPENDIX A

Appendix A1.–Numbers of coho salmon sampled for adipose clips and adipose clipped fish recovered in the Situk River escapement during 1993.

Date	Hours sampled	Gear	Fish sampled	Fish with adclips	Marked/ unmarked
Sport fishery interviews on lower Situk River					
1-Sep	3.00	Sport	38	0	
2-Sep	6.00	Sport	65	0	
3-Sep	2.50	Sport	51	0	
5-Sep	4.50	Sport	121	3	
6-Sep	1.25	Sport	46	5	
7-Sep	0.25	Sport	1	0	
9-Sep	4.25	Sport	36	0	
10-Sep	4.50	Sport	69	4	
12-Sep	2.00	Sport	38	1	
13-Sep	1.00	Sport	36	1	
14-Sep	1.00	Sport	5	0	
15-Sep	2.50	Sport	9	1	
16-Sep	2.25	Sport	28	1	
21-Sep	0.75	Sport	15	1	
22-Sep	1.75	Sport	19	0	
23-Sep	1.00	Sport	20	1	
Subtotal	38.50	Sport	597	18	0.0302
Inriver multiple gear sampling					
14-Sep		Rod & Reel	21	2	
15-Sep		Rod & Reel	5	0	
15-Sep		Carcass	46	0	
15-Sep		Seine	74	0	
16-Sep		SF Interview	20	1	
16-Sep		Carcass	4	0	
16-Sep		Seine	206	6	
17-Sep		Seine	266	11	
Subtotal		Multiple	642	20	0.0312
Pooled sampling					
1-Sep		Sport	38	0	
2-Sep		Sport	65	0	
3-Sep		Sport	51	0	
4-Sep		Sport	0	0	
5-Sep		Sport	121	3	
6-Sep		Sport	46	5	
7-Sep		Sport	1	0	
8-Sep		Sport	0	0	
9-Sep		Sport	36	0	
10-Sep		Sport	69	4	
11-Sep		Sport	0	0	
12-Sep		Sport	38	1	
13-Sep		Sport	36	1	
14-Sep		Sport	26	2	
15-Sep		Multiple	134	1	
16-Sep		Multiple	258	8	
17-Sep		Seine	266	11	
18-Sep		Sport	0	0	
19-Sep		Sport	0	0	
20-Sep		Sport	0	0	
21-Sep		Sport	15	1	
22-Sep		Sport	19	0	
23-Sep		Sport	20	1	
Total		Multiple	1,239	38	0.0307

Appendix A2.–Random and select recoveries of coded wire tagged coho salmon bound for the Situk River in 1993.

Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
51476	43760	7/17/93	GILLNET	29	212 00	4,385	1,963	19	18	16	16
15940	43761	8/3/93	GILLNET	32	183 10	136	39	1	1	1	1
34726	43335	8/26/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34727	43760	8/26/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34728	43760	8/26/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34729	43760	8/26/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34733	43760	8/27/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34730	43761	8/26/93	GILLNET	35	182 70	6,035	602	8	8	8	8
34688	42852	8/25/93	GILLNET	35	182 80	6,035	602	8	8	8	8
34689	43760	8/25/93	GILLNET	35	182 80	6,035	602	8	8	8	8
92374	42852	8/28/93	GILLNET	35	212 00	54,639	9,768	14	14	4	4
34906	42852	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34907	42852	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34938	42852	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34940	42852	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34910	43335	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34905	43760	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34908	43760	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34912	43760	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34913	43760	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34941	43760	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34943	43760	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34946	43760	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34904	43761	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34909	43761	9/1/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34939	43761	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34942	43761	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34944	43761	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
34945	43761	9/2/93	GILLNET	36	182 70	15,587	2,390	20	20	18	18
56572	42852	9/4/93	GILLNET	36	200/212	80,905	46,022	68	68	38	38
92377	42852	9/4/93	GILLNET	36	212 00	54,139	22,139	27	27	14	14
58585	43760	9/4/93	GILLNET	36	212 00	54,139	22,139	27	27	14	14
75177	43760	9/4/93	GILLNET	36	212 11	54,139	22,139	27	27	14	14
92382	43741	9/3/93	GILLNET	36	212 31	54,139	22,139	27	27	14	14
3802	42852	9/7/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3841	42852	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3835	43335	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3845	43335	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3849	43335	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3805	43760	9/7/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3827	43760	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3828	43760	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3837	43760	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3840	43760	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3843	43760	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3844	43760	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3850	43760	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3804	43761	9/7/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3825	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3830	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3831	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28

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Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
3832	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3833	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3834	43761	9/8/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3839	43761	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3842	43761	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3846	43761	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3847	43761	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3848	43761	9/9/93	GILLNET	37	182 70	34,057	3,118	32	31	28	28
3867	43335	9/10/93	GILLNET	37	182 80	34,057	3,118	32	31	28	28
3866	43760	9/10/93	GILLNET	37	182 80	34,057	3,118	32	31	28	28
3868	43760	9/10/93	GILLNET	37	182 80	34,057	3,118	32	31	28	28
58592	43761	9/10/93	GILLNET	37	200 20	14,459	7,903	14	14	3	3
75998	43761	9/10/93	GILLNET	37	200 20	14,459	7,903	14	14	3	3
92219	43761	9/10/93	GILLNET	37	200 20	14,459	7,903	14	14	3	3
92218	43335	9/10/93	GILLNET	37	212 00	31,496	12,706	20	20	8	8
3899	43760	9/14/93	GILLNET	38	182 40	34,202	6,962	50	50	44	44
3895	42852	9/13/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3897	42852	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3908	42852	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3913	42852	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3915	42852	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3916	42852	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3919	42852	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3920	42852	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25209	42852	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25217	42852	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3903	43335	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3904	43335	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3909	43335	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3962	43335	9/16/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25202	43335	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3898	43741	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3988	43741	9/16/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3896	43760	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3901	43760	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3906	43760	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3910	43760	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3970	43760	9/16/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25206	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25207	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25211	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25213	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25214	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25218	43760	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3902	43761	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3905	43761	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3907	43761	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3911	43761	9/14/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3918	43761	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3921	43761	9/15/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
3969	43761	9/16/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25201	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25203	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44

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Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
25204	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25205	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25212	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25215	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25216	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
25219	43761	9/17/93	GILLNET	38	182 70	34,202	6,962	50	50	44	44
76135	42852	9/15/93	GILLNET	38	200 20	36,133	14,818	30	27	14	14
76133	43760	9/15/93	GILLNET	38	200 20	36,133	14,818	30	27	14	14
92230	43335	9/15/93	GILLNET	38	200/212	100,312	46,261	105	101	35	25
76130	43761	9/15/93	GILLNET	38	200/212	100,312	46,261	105	101	35	25
25229	42852	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25234	42852	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25178	43335	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25198	43335	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25200	43335	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25223	43335	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25225	43335	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25235	43335	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25194	43741	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25230	43741	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25237	43741	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25180	43760	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25187	43760	9/22/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25188	43760	9/22/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25196	43760	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25221	43760	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25238	43760	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25177	43761	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25182	43761	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25183	43761	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25184	43761	9/21/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25191	43761	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25195	43761	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25197	43761	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25224	43761	9/23/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25231	43761	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
25236	43761	9/24/93	GILLNET	39	182 70	39,795	5,466	43	42	27	27
76337	43760	9/22/93	GILLNET	39	200/212	73715	37268	72	72	18	18
92239	43760	9/22/93	GILLNET	39	212 11	40,314	13,365	40	40	14	14
25263	42852	9/28/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25274	42852	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25279	42852	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25283	42852	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25288	42852	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25293	42852	10/1/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25294	42852	10/1/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25277	43335	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25286	43335	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25287	43335	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25289	43335	10/1/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25251	43760	9/27/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25278	43760	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25280	43760	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29

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Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
25282	43760	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25285	43760	9/30/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25295	43760	10/1/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25253	43761	9/27/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25258	43761	9/28/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25267	43761	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25271	43761	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25275	43761	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25276	43761	9/29/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25292	43761	10/1/93	GILLNET	40	182 70	19,407	6,303	44	42	29	29
25256	42852	9/28/93	GILLNET	40	182 80	19,407	6,303	44	42	29	29
25262	43335	9/28/93	GILLNET	40	182 80	19,407	6,303	44	42	29	29
25257	43761	9/28/93	GILLNET	40	182 80	19,407	6,303	44	42	29	29
25260	43761	9/28/93	GILLNET	40	182 80	19,407	6,303	44	42	29	29
25261	43761	9/28/93	GILLNET	40	182 80	19,407	6,303	44	42	29	29
25273	42852	9/29/93	GILLNET	40	183 10	870	122	1	1	1	1
15810	42852	7/17/93	TROLL	29	189 30	798,463	225,044	3,537	3,497	2,993	2,991
31075	43335	7/22/93	TROLL	30	116 12	798,463	225,044	3,537	3,497	2,993	2,991
15849	42852	7/23/93	TROLL	30	181 50	798,463	225,044	3,537	3,497	2,993	2,991
15903	43335	7/23/93	TROLL	30	181 50	798,463	225,044	3,537	3,497	2,993	2,991
15901	43761	7/23/93	TROLL	30	181 50	798,463	225,044	3,537	3,497	2,993	2,991
15813	43761	7/19/93	TROLL	30	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15841	42852	7/22/93	TROLL	30	183 10	798,463	225,044	3,537	3,497	2,993	2,991
15905	42852	7/26/93	TROLL	31	116 00	798,463	225,044	3,537	3,497	2,993	2,991
15925	43760	7/27/93	TROLL	31	183 10	798,463	225,044	3,537	3,497	2,993	2,991
15967	43760	8/4/93	TROLL	32	116 00	798,463	225,044	3,537	3,497	2,993	2,991
17749	43760	8/5/93	TROLL	32	154 00	798,463	225,044	3,537	3,497	2,993	2,991
15941	42852	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15944	42852	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15952	42852	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15950	43741	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15947	43761	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15951	43761	8/3/93	TROLL	32	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15975	43760	8/5/93	TROLL	32	183 10	798,463	225,044	3,537	3,497	2,993	2,991
11992	43760	8/13/93	TROLL	33	114 00	798,463	225,044	3,537	3,497	2,993	2,991
18413	43761	8/11/93	TROLL	33	181 00	798,463	225,044	3,537	3,497	2,993	2,991
34620	43761	8/12/93	TROLL	33	181 50	798,463	225,044	3,537	3,497	2,993	2,991
15997	42852	8/11/93	TROLL	33	181 60	798,463	225,044	3,537	3,497	2,993	2,991
34627	43761	8/12/93	TROLL	33	181 60	798,463	225,044	3,537	3,497	2,993	2,991
15978	42852	8/9/93	TROLL	33	183 10	798,463	225,044	3,537	3,497	2,993	2,991
34650	42852	8/13/93	TROLL	33	191 10	798,463	225,044	3,537	3,497	2,993	2,991
18390	42852	8/11/93	TROLL	33		798,463	225,044	3,537	3,497	2,993	2,991
19486	43760	8/28/93	TROLL	35	113 91	481,416	110,451	2,219	2,206	1,919	1,919
34732	42852	8/26/93	TROLL	35	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34735	43335	8/26/93	TROLL	35	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34687	43760	8/25/93	TROLL	35	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34736	43761	8/26/93	TROLL	35	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34682	42852	8/25/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34773	42852	8/26/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34782	42852	8/26/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34692	43335	8/25/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34757	43335	8/26/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34686	43760	8/25/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919

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Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
34776	43760	8/26/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34784	43761	8/26/93	TROLL	35	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34703	43335	8/26/93	TROLL	35	189 40	481,416	110,451	2,219	2,206	1,919	1,919
12294	43335	8/26/93	TROLL	35		481,416	110,451	2,219	2,206	1,919	1,919
12258	43760	8/24/93	TROLL	35		481,416	110,451	2,219	2,206	1,919	1,919
12295	43761	8/26/93	TROLL	35		481,416	110,451	2,219	2,206	1,919	1,919
31740	42852	9/3/93	TROLL	36	116 14	481,416	110,451	2,219	2,206	1,919	1,919
31725	42852	9/2/93	TROLL	36	181 60	481,416	110,451	2,219	2,206	1,919	1,919
31726	43761	9/2/93	TROLL	36	181 60	481,416	110,451	2,219	2,206	1,919	1,919
34903	42852	8/31/93	TROLL	36	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34947	43335	9/2/93	TROLL	36	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34915	43760	9/1/93	TROLL	36	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34916	43760	9/1/93	TROLL	36	183 10	481,416	110,451	2,219	2,206	1,919	1,919
34950	42852	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34977	42852	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34886	43335	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34951	43335	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34967	43335	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34878	43760	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34900	43760	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34873	43761	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34888	43761	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34902	43761	8/31/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34949	43761	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34958	43761	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34971	43761	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
34986	43761	9/3/93	TROLL	36	189 30	481,416	110,451	2,219	2,206	1,919	1,919
3820	42852	9/8/93	TROLL	37	183 10	481,416	110,451	2,219	2,206	1,919	1,919
3836	42852	9/9/93	TROLL	37	183 10	481,416	110,451	2,219	2,206	1,919	1,919
3821	43760	9/8/93	TROLL	37	183 10	481,416	110,451	2,219	2,206	1,919	1,919
3818	43761	9/7/93	TROLL	37	183 10	481,416	110,451	2,219	2,206	1,919	1,919
31845	43761	9/5/93	TROLL	37	183 10	481,416	110,451	2,219	2,206	1,919	1,919
3858	43760	9/10/93	TROLL	37	189 30	481,416	110,451	2,219	2,206	1,919	1,919
3869	43760	9/10/93	TROLL	37	189 30	481,416	110,451	2,219	2,206	1,919	1,919
3813	43761	9/7/93	TROLL	37	189 30	481,416	110,451	2,219	2,206	1,919	1,919
28098	42852	9/16/93	TROLL	38	181 00	195,533	44,327	1,015	1,010	914	914
28100	43760	9/16/93	TROLL	38	181 00	195,533	44,327	1,015	1,010	914	914
28094	43761	9/16/93	TROLL	38	181 00	195,533	44,327	1,015	1,010	914	914
28292	43741	9/18/93	TROLL	38	189 00	195,533	44,327	1,015	1,010	914	914
31894	42852	9/12/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
31904	42852	9/12/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
25166	43335	9/17/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
25173	43741	9/17/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
3879	43760	9/13/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
3948	43760	9/16/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
15890	43760	9/17/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
25171	43760	9/17/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
31901	43760	9/12/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
3997	43761	9/16/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
15877	43761	9/16/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
25158	43761	9/17/93	TROLL	38	189 30	195,533	44,327	1,015	1,010	914	914
27850	43761	9/14/93	TROLL	38		195,533	44,327	1,015	1,010	914	914
28121	43761	9/15/93	TROLL	38		195,533	44,327	1,015	1,010	914	914

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Appendix A2.–Page 6 of 6.

Head number	Tag code	Recovery date	Gear	Stat week	Harvest district	*H*	*n*	*a*	*a'*	*t*	*t'*
28494	43761	9/21/93	TROLL	39	189 00	195,533	44,327	1,015	1,010	914	914
28569	43761	9/21/93	TROLL	39	189 00	195,533	44,327	1,015	1,010	914	914
SELECT RECOVERIES											
2377	42852	7/31/93	TROLL	31							
17806	43760	8/2/93	TROLL	32							
17839	43761	8/11/93	TROLL	33							
17857	43761	8/12/93	TROLL	33							
34661	43761	8/11/93	TROLL	33	181 60						
34671	42852	8/13/93	TROLL	33	189 30						
34675	42852	8/13/93	TROLL	33	189 30						
34864	42852	8/27/93	TROLL	35	189 30						
34859	43760	8/27/93	TROLL	35	189 30						
3783	43335	9/4/93	TROLL	36	189 30						
3788	42852	9/4/93	TROLL	36	189 30						
27816	43761	9/7/93	TROLL	37							
35000	43335	9/5/93	TROLL	37	181 60						
27804	43760	9/7/93	TROLL	37							
27809	43760	9/7/93	TROLL	37							
27814	43760	9/7/93	TROLL	37							
26657	43335	9/16/93	TROLL	38							
26660	43335	9/16/93	TROLL	38							
28687	43335	9/17/93	TROLL	38							
28691	42852	9/17/93	TROLL	38							
25321	43760	9/12/93	TROLL	38	189 30						
25326	43760	9/12/93	TROLL	38	189 30						
26695	43335	9/22/93	TROLL	39							
26701	43335	9/22/93	TROLL	39							
26705	42852	9/22/93	TROLL	39							
26708	42852	9/22/93	TROLL	39							
26722	43761	9/22/93	TROLL	39							
26723	42852	9/22/93	TROLL	39							
26746	42852	9/23/93	TROLL	39							
26775	43335	9/24/93	TROLL	39							
26836	43741	9/24/93	TROLL	39	189						
28166	43335	9/23/93	TROLL	39	189						
28168	43335	9/23/93	TROLL	39	189						
28193	43741	9/23/93	TROLL	39	189						
28327	42852	9/19/93	TROLL	39							
28329	43761	9/19/93	TROLL	39							
28331	43335	9/19/93	TROLL	39							
26707	43760	9/22/93	TROLL	39							
26729	43760	9/23/93	TROLL	39							
26749	43760	9/23/93	TROLL	39							
26751	43760	9/24/93	TROLL	39							
26785	43760	9/24/93	TROLL	39							
28165	43760	9/23/93	TROLL	39	189						
28186	43760	9/23/93	TROLL	39	189						
28324	43760	9/19/93	TROLL	39							
28740	43760	9/19/93	TROLL	39							
69092	43761	9/3/93		36	182 70						
69094	42852	9/15/93		38	182 70						
60507	43760	8/27/93		35	183						

Appendix A3.–Computer data files concerning data on smolt in 1992 and subsequent estimates for adults in 1993.

FILE NAME	DESCRIPTION
SITUK.TXT	Coded wire tagging release summaries for coho salmon smolt released into the Situk River during 1992.
92SITUK.XLS	Excel workbook of screw trap catches of coho salmon smolt (CATCH), the number of smolt marked by size and type of mark from the upper site (MARKS), the number of smolt caught, sampled for marks, and sampled for age and length at the lower site (NUMSAM), age-length data collected at the lower site (AGELEN), the estimated age composition at the lower site (AGECOMP), the number of smolt sampled for age-length at the lower site by size (SAMSIZE), individual lengths of marked fish recaptured at the lower site (RECAPS), and water temperature and level recorded at the upper trap site (TEMPDEPTH).
93SITUK.XLS	Excel workbook of CWTs recovered in fisheries (sheets 1,2) and associated estimate of θ (sheet 8), smolt estimates (sheet 4), frequency of CWT recoveries by fishery (sheet 5), harvest by fishery (sheets 6,7), mean date of harvest calculations (sheet 7), data and CWT expansions (sheet 3).
SITUKCOH.DOC	WORD 6.0 (Windows) file of this FDS report.